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Description

HARMONIC MIXER BASED TELEVISION TUNER AND METHOD OF PROCESSING A RECEIVED RF SIGNAL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation-in-part of Application No. 10/604018, filed on June 22, 2003,entitled "Passive Harmonic Mixer" and assigned to the same assignee, the contents of which are incorporated herein by reference.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to television tuners, and more particularly, to a double conversion television tuner using a harmonic mixer architecture with no second intermediate frequency to process a received RF signal.

[0004] 2. Description of the Prior Art

[0005] One of the most significant costs in television manufacturing is the cost of the tuner. The typical cost of a televi-

sion (TV) tuner is in the neighborhood of $15.00, which, relative to the cost of the entire television set, is very substantial. Furthermore, with the increasing desire to integrate TV functions into personal computer (PC) systems and other electronic devices, the cost of the tuner needs to be reduced. Part of the solution to reducing tuner cost is to reduce the number of components in the tuner.

[0006] Traditionally, tuners have been comprised of two basic components. The first component performs high frequency to intermediate frequency (RF to IF) conversion. Subsequently, the second component performs IF to baseband conversion. The TV tuner was originally designed for broadcast television reception within a television set, which is essentially a stand-alone unit containing a cathode ray picture tube. As such, TV tuners were originally integral parts embedded in a single-purpose device.

[0007] Presently, however, state-of-the-art consumer electronic devices use TV tuners that are not a built-in part of a television set. The tuner is a separate element that is connected to a cathode ray picture tube at some point, but the tuner is not an integral part of the monitor. As previously mentioned, TV tuners may be fabricated on circuit boards and then installed in personal computer systems,

thereby allowing the PC to function as a television set. These tuners convert a radio frequency television signal into a baseband (or low frequency) video signal, which can then be passed on to other elements in the PC for video processing applications.

[0008] The circuit component that performs the RF-to-IF conversion typically comprises one or two integrated circuits and numerous discrete elements such as inductors, capacitors and/or transistors. The IF-to-baseband conversion typically includes another integrated circuit, several filter elements, such as ceramic filters and SAW filters, a series of tuning and control elements, such as resistors and potentiometers, variable inductors and/or capacitors, and some other additional external components. Thus, the complexity of the tuner is fairly high and typically there may be between 100 and 200 elements on a circuit board. Furthermore, state-of-the-art TV tuners still require that each tuner be aligned by manual tuning before leaving the factory. This manual tuning is one of the most expensive costs associated with the manufacturing process and an important factor in the cost of tuners.

[0009] Broadcast television tuners of the past have gone through an evolution over a period of more than 60 years. The

earliest tuners utilized vacuum tube technology and required that the minimum number of vacuum tubes possible be used due to their cost, power consumption and dimensions. Therefore, passive components, such as resistors, capacitors, inductors and transformers, were used as much as possible in most designs. This style of design continued until about 1960 when TV tuner components, particularly vacuum tubes began to be replaced by bipolar and MOS transistors. However; the active device count still defined the cost and size limits of TV tuners and active device count minimization continued.

[0010] In the early 1970's the integrated circuit became viable as an element in the television tuner and the design techniques were dramatically changed. Many functions of the tuner utilizing only one tube or transistor were being replaced with 4 to 20 individual transistors which could perform the same function with better precision, less space, less power, less heat generation, and lower cost. The introduction of the integrated circuit was gradual, first encompassing only low frequency elements and then eventually high frequency active elements. Nonetheless, many passive elements external to the integrated circuits remained in TV tuner designs.

[0011] One advance, the SAW (surface acoustic wave) filters made a significant change in that several manually tuned inductors and capacitors could be removed from the tuners and receive-filtering performance could be improved within a much smaller space and at reduced cost. However, the SAW filter, which is fabricated on a ceramic substrate, cannot be integrated on a silicon wafer with the rest of the active circuitry and must therefore remain a discrete component in the final design. The trend of the 1980's was to miniaturize all of the passive components and simplify their associated manual tuning at the factory. In recent years, TV tuners have been reduced in size from requiring fairly large enclosures, about 2" x 5" x 1", to much smaller enclosures, about 1/2" x 2" x 3/8". There is a high premium placed on small size because TV tuners are being used in smaller and smaller computers, television sets, and VCRs. As the equipment in which tuners are used becomes smaller, the size of the TV tuner must also decrease.

[0012] As the size of the tuner is reduced, and as tuners are used in a wider variety of devices, cost becomes more critical and must be reduced as much as possible in order not to represent a large portion of the final product cost. When a

tuner is used in a television set, the tuner size is less critical because the television set inherently has a large mass. But when a tuner is used in other electronic equipments, space becomes a premium and the footprint of the tuner becomes critical.

[0013] Fig.1 shows a highly integrated television tuner 100 on a single microcircuit as disclosed by US Patent No. 5,737,035. The television tuner 100 includes an adjustable low noise amplifier 101, a first mixer 102, a first local oscillator 104, a band-pass filter 106, a second mixer 108, being an image rejection type mixer, a second local oscillator 110, a first intermediate frequency amplifier 112, a second band-pass filter 114, and a variable intermediate frequency amplifier 116. However, as the television tuner 100 requires the use of a special image rejection mixer for the second mixer 108, the cost of the tuner is increased. Additionally, the first local oscillator 104 is used in conjunction with the first mixer 102 to up-convert a particular channel selected from an incoming RF signal. This means the first local oscillator 104 must be a variable frequency local oscillator having a large operating frequency range. Because the phase noise over the operating frequency range of the first local oscillator 104 must meet

a specific phase noise requirement, typically 84 dBC/Hz, a plurality of VCOs having smaller frequency ranges, and therefore lower phase noise, must be used. This again increases the complexity and cost of the television tuner 100. Accordingly, aneed exists for a tuner not having these requirements in order to reduce the cost.

SUMMARY OF INVENTION

[0014] It is therefore a primary objective of the claimed invention to provide a double conversion television tuner using a harmonic mixer architecture with no second intermediate frequency, to solve the above-mentioned problems and reduce the overall cost.

[0015] According to the claimed invention, a television tuner is disclosed comprising a first mixer having inputs coupled to a received RF signal for converting the received RF signal to a intermediate frequency signal, a band-pass filter coupled to the first harmonic mixer, a second harmonic mixer coupled to the band-pass filter for directly converting the intermediate frequency signal to an in-phase baseband signal, and a third harmonic mixer coupled to the band-pass filter for directly converting the intermediate frequency signal to a quadrature-phase baseband signal.

[0016] Also according to the claimed invention, a method of processing a received RF signal. The method comprising mixing the received RF signal to produce an intermediate frequency signal, filtering the intermediate frequency signal to produce a pass band signal, mixing the pass band signal to produce a in-phase baseband signal, and mixing the pass band signal to produce a quadrature-phase baseband signal.

[0017] These and other objectives of the claimed invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0018] Fig.1 is a highly integrated television tuner according to the prior art.

[0019] Fig.2 is a double conversion television tuner architecture according to the present invention.

DETAILED DESCRIPTION

[0020] Fig.2 shows a double conversion television tuner 200 architecture according to an embodiment of the present invention. The television tuner 200 includes a low noise

amplifier 202, a first harmonic mixer 204, a first local oscillator 206, a band-pass filter 210, a second local oscillator 212, a second harmonic mixer 214, a first in-phase baseband amplifier 216, an in-phase low-pass filter 218, a second in-phase baseband amplifier 220, a third harmonic mixer 222, a first quadrature baseband amplifier 224, a quadrature low-pass filter 226, and a second quadrature baseband amplifier 228.

[0021] A received radio frequency signal (RF_IN) is amplified by the low noise amplifier 202 and coupled to an input of the first harmonic mixer 204. The harmonic mixer 204 is used in the embodiment of the present invention, however, other kinds of mixers can also be used here. The structure and the operation of the harmonic mixer are disclosed in the co-pending application entitled "Passive Harmonic Mixer", Ser. No. 10/604018, filed on Jun. 22, 2003 and assigned to the same assignee, the contents of which are incorporated herein by reference. The first local oscillator 206 operates at a variable first frequency and provides both a 0° phase-delayed reference signal and a 90° phase-delayed reference signal. The output of the first harmonic mixer 204 has a desired channel in the received RF signal positioned at 1220MHz or 1090Mhz, according

to the center frequency of the bandwidth of the band-pass filter 210. The output of the band pass filter 210 is coupled to the inputs of both the second harmonic mixer 214 and the third harmonic mixer 222. The second local oscillator 212 operates at a constant second frequency of 610MHz (1220Mhz input) or 545Mhz (1090Mhz input) and provides a 0° phase-delayed reference signal, a 45° phase-delayed reference signal, a 90° phase-delayed reference signal, and a 135° phase-delayed reference signal. The output of the second harmonic mixer 214 is an in-phase baseband signal, and the output of the third harmonic mixer 222 is a quadrature baseband signal. The first in-phase baseband amplifier 216, the in-phase low-pass filter 218, and the second in-phase baseband amplifier 220 filter and amplify the in-phase baseband signal for processing in later stages in the TV receiver. Likewise, the first quadrature baseband amplifier 224, the quadrature low-pass filter 226, and the second quadrature baseband amplifier 228 filter and amplify the quadrature baseband signal for processing in later stages in the TV receiver. Together, the output of the second in-phase amplifier I and the output of the second quadrature amplifier Q form a baseband video signal, which is then

passed on to other video processing elements.

[0022] Because a harmonic architecture is used, the frequency range of the 0° phase-delayed reference signal and the 90° phase-delayed reference signal output by the first local oscillator 206 is between 635MHz and 1040MHz (when a SAW filter 210 having a center frequency of the bandwidth, 1220Mhz, is used). This is one half the frequency range of the conventional TV tuner shown in Fig.1 and means that the VCO architecture implementing the first local oscillator 206 of the present invention is greatly simplified. The same specific phase noise requirement, typically 84 dBC/Hz, can be met by using approximately half the number of VCOs that are required in the conventional TV tuner. This both simplifies the design of the television tuner and significantly reduces the cost of the television tuner 200 implementation.

[0023] The second stage of the television tuner 200 forms a direct conversion receiver (DCR). The intermediate frequency signal output by the band-pass filter 210 is directly converted to baseband. The direct conversion architecture includes an In-phase (I) pathway and a Quadrature-phase (Q) pathway for directly converting the intermediate frequency signal to a baseband signal. Since the

direct conversion architecture is used, there is no second intermediate frequency. In addition, in this embodiment of the present invention, two harmonic mixers are used. One in the In-phase (I) pathway and one in the Quadrature-phase (Q) pathway. Thus, the second local oscillator 212 operates at a constant 610MHz (when a SAW filter 210 having a center frequency of the bandwidth, 1220Mhz, is used), one half the frequency of the second local oscillator 108 of the Fig.1. As such, the additional frequency conversion stage required in the conventional television tuner to convert the output IF2_OUT to baseband is not required. Furthermore, the in-phase low-pass filter 218 and the quadrature low-pass filter 226 are simple low-pass filters that can be fabricated internal to an integrated circuit (IC). The conventional TV tuner shown in Fig.1 uses the bandpass filter 114, which has image rejection functions and is normally fabricated off-chip. By using a direct conversion architecture with harmonic mixer implementation according to the present invention, the complexity and cost of the television tuner 200 is greatly reduced.

[0024] The present invention uses a direct conversion architecture with harmonic mixer architecture to convert a received RF signal to baseband using only a single interme-

diate frequency. In this way, the operating frequency range of the variable local oscillator is reduced by one half. This reduces the number of VCOs that must be used to ensure the phase noise of the first local oscillator meets the required phase noise levels. Additionally, by using the direct conversion architecture, the in-phase low-pass filter 218 and the quadrature low-pass filter 226 can be implemented on-chip, and the output of the second and the third harmonic mixers is the baseband video signal. The baseband video signal can then be directly passed on to other video processing elements avoiding the use the second intermediate frequency to baseband conversion required in the conventional TV tuner.

[0025] Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.